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Demonstration Integrated Knowledge-Based System for Estimating Human Error Probabilities

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Human Reliability Analysis (HRA) is currently comprised of at least 40 different methods that are used to analyze, predict, and evaluate human performance in probabilistic terms. Systematic HRAs allow analysts to examine human-machine relationships, identify error-likely situations, and provide estimates of relative frequencies for human errors on critical tasks, highlighting the most beneficial areas for system improvements. Unfortunately, each of HRA's methods has a different philosophical approach, thereby producing estimates of human error probabilities (HEPs) that are a better or worse match to the error likely situation of interest. Poor selection of methodology, or the improper application of techniques can produce invalid HEP estimates, where that erroneous estimation of potential human failure could have potentially severe consequences in terms of the estimated occurrence of injury, death, and/or property damage.

Objectives

In this session, we propose to demonstrate and evaluate a developmental-level expert system that assists human factors practitioners in determining appropriate human error probabilities (HEPs) to include in human reliability analyses (HRAs). The objectives of the session are three-fold:

- to expose risk/human factors analysts to a new tool that provides more accurate estimates of human error probabilities than currently available methods;
- to solicit information from novice and expert users regarding (a) the usefulness of the tool for various levels of human reliability analysis and (b) the validity of the estimates provided by the system; and
- to obtain user opinions on additional features that the system should have, to guide future development.

Description of the Subject Matter

Background

HRA is a collection of at least ten methodologies used to analyze, predict, and evaluate human performance in probabilistic terms. HRA identifies under what circumstances human errors are most likely, estimates the anticipated error rate for individual tasks, and highlights the most beneficial areas for system improvements. Unfortunately, the practitioner wishing to use HRA is confronted with a bewildering set of choices -- each of the methods available has a different philosophical approach, thus, producing estimates that are a better or worse match to the situation of interest. Many analysts, therefore, rely on the most common of the methods (usually Swain and Guttman's Technique for Human Error Rate Prediction -- THERP, 1983) in spite of the fact that they may not have been designed with the task of interest in mind. (THERP, for instance, has mainly been developed with an eye toward application in the nuclear power industry.) Poor selection of methodology can produce invalid estimates. Even worse, there may be no "best match" of methodology to situation, and the analyst is left to integrate estimates derived from multiple sources without any advice as to the most appropriate combination strategy. Either of these situations may result in gross overestimates of human reliability, which has potentially severe consequences in terms of the occurrence of unanticipated accidents causing injury, death, and/or property

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damage. To address these situations, Los Alamos National Laboratory has developed a prototypical HRA-based expert system. When finished this tool will accept user input to define the critical task, determine a "best match HRA technique" (based on available data and the specific situation), and then derive an appropriate HEP, error factor, and an estimate of confidence regarding the HEP's utility in the present circumstances.

Project Description

Many of the HRA methodologies have associated databases (electronic or hard copy) of human error probability estimates. The first step in the project was to gather these data sources, convert any non-electronic ones to electronic format, and create a database containing the data and information on the underlying assumptions inherent in each method.

The second step, was to develop a prototype expert system that:
(1) allows the analyst to input information about the situation or task being analyzed,
(2) compares the analyst's situation to the HRA methods, and selecting a "philosophical best fit" match of situation to method;
(3) provides the analyst with a viable HEP, error factor, and estimated level of confidence in the result; and
(4) provides hypertext help within the expert system to define terms and HRA jargon, explain underlying assumptions, and reveal how the knowledge-based rules were used to get to the final output.

The first phase of expert system development will be completed in time for the proposed demonstration. At that point, the expert system will include (at a minimum) the three most commonly used HRA methodologies, namely, Human Cognitive Reliability (HCR, Hannaman and Spurghin, 1984), Accident Sequence Evaluation Program (ASEP, Swain, 1987), and THERP. In addition, this tool will include a recently developed technique that employs a Bayesian update of a given HEP, using real, plant-specific operational data from various sources (Auflick, Morzinski, Eide, and Houghton, 1996).

Finally, we plan to equip the expert system with an additional suite of tools, such as the capability to draw fault and event trees based on the task information previously provided, such that an analyst can complete an entire HRA using one software package. Exactly what the suite of tools will be remains to be determined -- this is one of the areas about which we intend to query session participants.

Presentation Format

This demonstration will take the audience through a brief overview of the expert system. Specifically, the author will demonstrate how the tool works by taking participants through an actual HRA scenario that requires the generation of a viable HEP. Specific attention will be focused on how the data is input, how the rules are fired, the results, and how the hypertext links can help the user to understand the HRA process. After the general demonstration, the HRA tool will be available during breaks and before or after the risk assessment sessions, so that interested parties can experiment with the tool's capabilities. For this part of the demonstration, we will develop three scenarios, based on real experiences in performing HRA, for which no single currently available method is ideally suited, but for which the preferred available method is either HCR, ASEP, or THERP respectively (i.e., one scenario per method). Each scenario will provide an opportunity for attendees to exercise the major features of the system, including inputting information about the task, obtaining definitional information using hypertext "hot buttons", generating a HEP, associated error factor and confidence estimate, and reviewing the rules that generated the HEPs.

Each participant will be provided with a scenario, which places him or her in the role of an HRA analyst who has been asked to solve a specific problem. Manuals and online help will guide them through the analysis using the expert system software. Documentation for the three methodologies included in the expert system will also be available upon request. Each participant will complete an excursion through the expert system, and the session will formally end when the HEPs are generated. Following their participation in the demonstration, attendees will be asked to provide information relative to system evaluation, including such things as confidence in the validity of the estimate, ease of use, and value provided (i.e., versus using the various methods in stand-alone format).

Expected Benefits to Attendees

The primary benefit to attendees will be increased awareness of human reliability methods and the issues and challenges associated with them, and exposure to a new method for addressing those issues. On a more philanthropic note, attendees will also play a role in the advancement of human factors research and development, as their input will be used to help determine the course of our future efforts.

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